AN OVERVIEW OF THE MECHANICAL DESIGN OF THE ATLAS PULSED POWER MACHINE

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Abstract

Atlas is a pulsed-power facility being designed at Los Alamos National Laboratory to perform high-energy density experiments in support of Science-Based Stockpile Stewardship and basic research programs[1]. Atlas will consist of 24 individual maintenance units, each consisting of 4 240-kV Marx units. Maintenance units are contained in large oil tanks arrayed in a circle about a central target chamber. Total stored energy of the capacitor bank will be 23 MJ. Maintenance units will discharge through an output shorting switch into a vertical tri-plate transmission line, and from there into a transition area/collector inside a large vacuum chamber. An overview of mechanical design aspects of the Atlas machine is presented. These include Maintenance unit design and design of the tri-plate transmission line and transition region. Findings from fabrication and testing of prototype systems will be discussed.

I. INTRODUCTION

Atlas is a 23 MegaJoule, 240 kV pulsed power facility being designed and constructed at the Los Alamos National Laboratory to perform high-energy density experiments in support of the Science-Based Stockpile Stewardship program. Atlas has completed its design phase and is now in the early stages of its construction. Procurements will soon be let for the steel support and tanks and for components of the maintenance units.

The purpose of this paper is to discuss the overall mechanical design of Atlas, and to touch on design aspects of individual components that may be of interest. Papers that discuss some components in detail, along with detailed results from testing, are included in this volume of proceedings.

II. MACHINE CONFIGURATION

The Atlas machine is comprised of 96 Marx modules that are contained in 12 oil tanks arranged in a circular fashion around a central target area. The basic arrangement of Atlas is shown in figure 1.

The Marx units are arranged in a configuration called a Maintenance Unit (MU), each MU consisting of 4 240 kV Marxes. Each of the 12 oil tanks contains 2 MUs, for a total of 8 Marxes per oil tank.

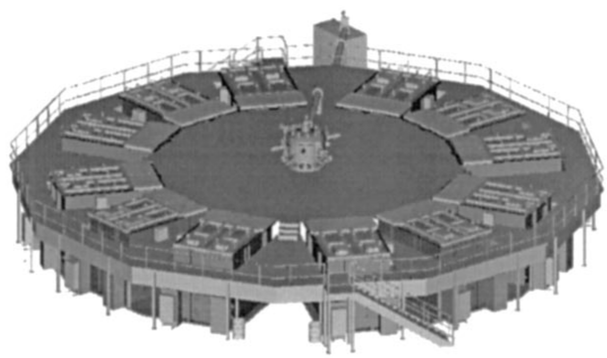

Fig. 1: 3-D CAD rendering of Atlas machine

Each MU is connected via 14 RG 220 cables through a load protection switch (LPS) to an oil-insulated vertical tri-plate transmission line that carries the Marx module discharge current to the centrally-located parallel-plate collector called the transition region. There are 24 vertical tri-plate lines in Atlas. The tri-plate lines are contained within oil tanks. A steel superstructure serves to support the tri-plate line tanks. Aluminum diamond-tread plate serves as both a covering for the oil tanks and a platform for personnel and diagnostic support.

III. MAINTENANCE UNIT DESIGN

The Atlas MU is designed for modularity and ease of assembly[2]. The primary structure of the MU is ¾ inch thick plates of G-10 fiberglass composite. Figure 2 shows the design of the G-10 structure from ½ of a maintenance unit. The structure is designed to be assembled in halves for ease of handling. A Marx module is assembled in the upper and lower half; the upper half is then bolted to a lid that hangs from a set-down rack. When the upper portion is bolted in place, the lower portion is raised up to the upper portion and the two sections are bolted together.

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14. ABSTRACT
Atlas is a pulsed-power facility being designed at Los Alamos National Laboratory to perform high-energy density experiments in support of Science-Based Stockpile Stewardship and basic research programs~. Atlas will consist of 24 individual maintenance units, each consisting of 4 240-kV Marx units. Maintenance units are contained in large oil tanks arrayed in a circle about a central target chamber. Total stored energy of the capacitor bank will be 23 MJ. Maintenance units will discharge through an output shorting switch into a vertical tri-plate transmission line, and from there into a transition area/collector inside a large vacuum chamber. An overview of mechanical design aspects of the Atlas machine is presented. These include Maintenance unit design and design of the t&plate transmission line and transition region. Findings from fabrication and testing of prototype systems will be discussed.

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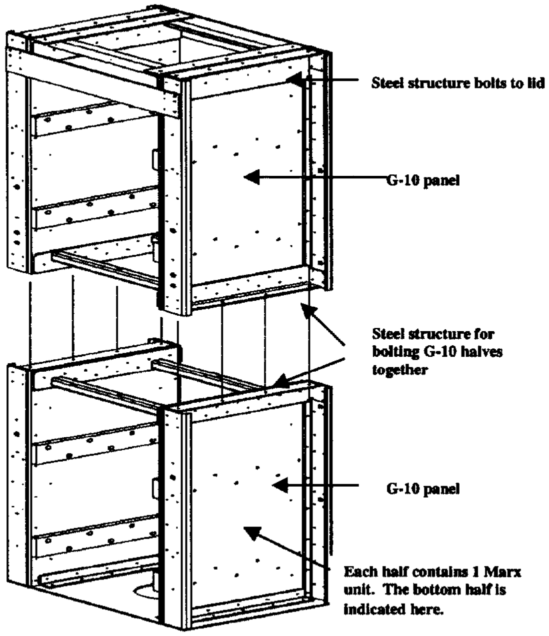

Fig. 2: Atlas G-10 Marx cabinet

The bolted joints are made in steel angle. Steel was selected over G-10 due to steel's superior engineering properties. Caution was taken to ensure that the steel was not located in any regions where the electric field strength might be a concern.

Figure 3 shows a 3-D CAD representation of the MU hanging in its set-down rack. The bolted joints where the upper and lower halves are connected should be evident.

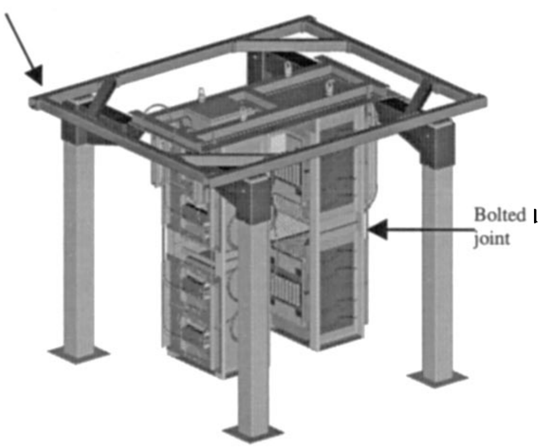

Figure 3: Assembled MU in set-down rack

The set-down rack is used only for assembly, disassembly, and maintenance of the MUs. It provides for a dry area with forklift access from critical angles so that the individual Marxes can be brought in and bolted up to the lid. It is a free-standing structure that is bolted to the concrete, and is stable enough for personnel to work under. The top portion of the set-down rack can be raised and lowered to make the upper MU components more accessible.

III. LPS AND TRANSMISSION LINE

A cross-section of the Atlas machine showing the MU in a tank is shown in figure 4.

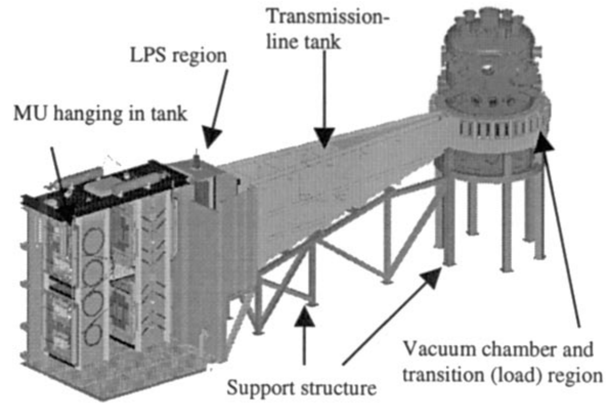

Figure 4: Cross-section of Atlas

Once the MU is assembled in its set-down rack it is disconnected from the rack and placed in the oil tank. Cables run from the Marxes through a cable header to a load-protection switch (LPS), which serves to protect the load from a Marx module prefire. The LPS is closed during charging and essentially provides a short across the VTLs. The switches have a measured opening time of 250 ms.

The cable header allows the MU to be removed from a tank while leaving the LPS in place. RG-220 cables run from the MU to the one side of the header, and from the opposite side of the header to the MU. The cable header and LPS are shown in figure 5. Half of the cable header assembly is part of the MU, and half stays with the LPS.

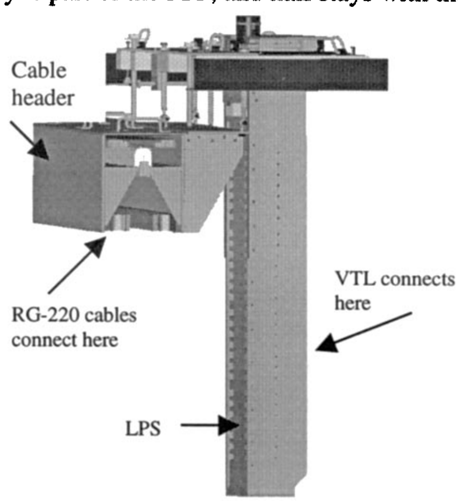

Figure 5: Cable header and LPS

The LPS's are hard connected to an oil-insulated vertical tri-plate transmission line (VTL). The VTL consists of three parallel plates, the center plate being the

plate carrying current to the load and the outer plates being the return path. Each plate is approximately 6 m in length, and is 2 m tall at the MU end and approximately 0.3 m tall near the machine center. The spacing between the plates is 2 cm over the entire length, and this dimension is controlled by a series of insulators that lock the three plates together. In order to closely control the location and fit-up of the insulators, each three-plate VTL stack is co-machined and has the insulator holes match drilled as a single unit. A 3-D CAD rendering of a VTL assembly is shown in figure 6.

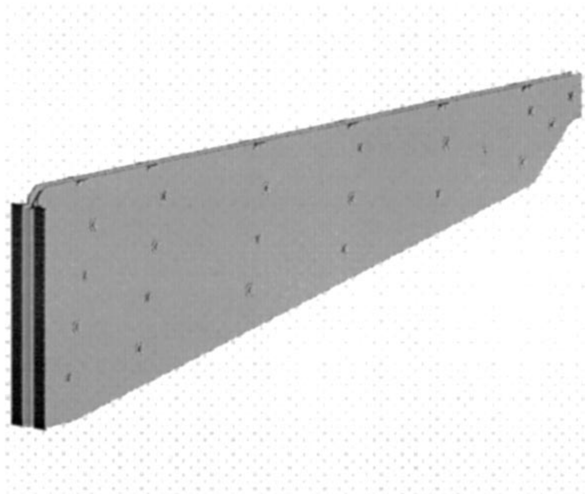

Figure 6: Vertical Tri-Plate Assembly

Each VTL plate is machined from a special mill run plate of 6061-T6 Aluminum. Two VTL plates can be cut from a single mill run plate that is nominally 96" by 240". Manufacturing the VTL plates in this manner eliminates the need for any sort of joint in the plate center and obviates any of the related problems that a joint might cause. Mill flatness was determined to be sufficient.

At the machine center, two things need to take place. First, the current, which has been flowing in a vertical plane in the VTLs, needs to be transitioned to flow in a horizontal plane. Second, the two return, or "ground", plates need to be combined into one horizontal plate. Combining the two ground plates and transitioning the current to a horizontal plane allow the load to be place in machine center such that diagnostics easily access the center of the target area.

The area that accomplishes the ground plate combination and the rotation of current flow is called the transition region. An exploded view CAD rendering of the transition region is shown in figure 7.

The VTLs attach to the ground and high voltage transition by means of removable current joint assemblies. Each of the two ground (or return) tri-plates is individually attached to the ground transition. Similarly, the high voltage (center) tri-plate attaches to the high-voltage transition.

The transition pieces are machined out of large forgings of 6061-T6 aluminum. The high voltage transition's finished size is 2.3 m diameter and 0.35 m thick. It weighs approximately 3988 pounds in its finished state. The size of the ground transition is similar, and its final weight is 3183 pounds.

The attachment ring attaches to the VTL tanks (fig. 4) and the base plate, and serves as part of the oil containment system. The attachment ring is machined from a solid cast stainless steel ring. Various insulators are attached to the base plate and transition conductors.

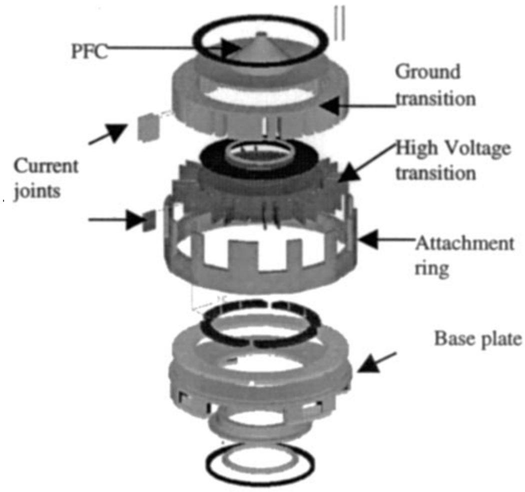

Figure 7: Transition Assembly

The massive transition region is supported on the base plate, which attaches in turn to a center support structure shown in fig. 4. Extensive finite element analysis was done to ensure that the center structure was stable enough to support the weight of the transition section and any dynamic loads that might obtain from firing the machine.

IV: CONCLUSIONS AND SUMMARY

Atlas is in the process of constructing and firing a first-article that essentially consists of the hardware shown in figure 4, minus the transition section. A dummy load will be used to simulate the transition region. The MU tank and a full MU have been manufactured. Insertion of the MU into the oil tanks has proven to be very straightforward. Test firing of the MU into a dummy load at 60 kV has been accomplished. The next step is to attach an LPS and a half-section VTL to the MU and attach the output to a dummy load, then proceed with full voltage, full current testing. Testing with a full-scale VTL will follow.

A full-scale, fully operational LPS has been constructed and tested with an impulse tester. It has successfully undergone more than 1000 cycles of mechanical operation and has shown minimal wear on current contacts. The LPS has seen 17 successful shots at voltages ranging from 470-520 kV. We expect the LPS to undergo full current, full voltage tests in August 99.

Construction of the steel support structure and tanks is scheduled to being in July of 1999. Installation of the structure and tanks is to begin in December 1999.

Installation of pulsed-power components will begin in the March 2000, time frame, or sooner if schedule permits.

V. REFERENCES

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